ECONOMIC LOAD DISPATCH USING SIMPLE AND REFINED GENETIC ALGORITHM

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ABSTRACT

In present era it is important to economize generation cost by satisfying operational constraints. Economic load dispatch is important tool to solve this problem. This paper presents the simple genetic algorithm (SGA) and refined genetic algorithm (RGA) method applied to economic dispatch problem which accounts for minimization of cost along with operational constraints. As lambda iteration method requires exact adjustment of lambda and it does not give global optimum solution. Results proved that GA based technique give global optimum solution and by varying probabilities of crossover and mutation computer usage time can be drastically reduced in RGA. Elitism is a technique which save early solution by ensuring the survival of highest fittest string. So it improves performance capability of Genetic Algorithm

KEYWORDS: *Economic Dispatch, Simple genetic algorithm, Refined genetic algorithm, Lambda Iterative technique.*

I. INTRODUCTION

Among the major economy security function in power systems operation, economic dispatch ranks the highest. It is defined as the process of allocating generation levels to the generating units in the mix, so that the system load may be supplied most economically, under all unit and system equality and inequality constraints [2]. It is also defined as production level of each plant so that total cost of generation and transmission is minimum for prescribed schedule of load So economic load dispatch problem is to reduce fuel cost to minimum so that system must operate economically.
Various analysis techniques can be used to solve economic load dispatch such as:

- Lambda Iteration method.
- Gradient search method.
- Reduced gradient with linear constraints.
- Newton method.

Most of these techniques suffer from many drawbacks such as difficult approach, more convergence time and lack of reliability [18]. Among these techniques Lambda Iteration method is faster. In lambda Iteration Method Incremental cost curves for all units are plotted and operating point is found where all units have minimum fuel cost and at same time specified demand is obtained but this technique is difficult in approach and due to complexity and non-monotonicity of the problem it may be unable to give global optimum solution so to overcome these problems and to find global optimum

solution for economic dispatch problem with minimum cost artificial intelligence techniques can be used. In this paper to overcome these drawbacks Genetic Algorithm is used [4].
Genetic Algorithms (GAs) are global optimization techniques based on the operations observed in natural selection and genetics. GAs, unlike strict mathematical methods, have the apparent ability to adapt to non-linearity and discontinuities commonly found in power systems. Simple genetic algorithm (SGA) and refined genetic algorithm (RGA) are two broad categories of GA algorithms [1]. They operate on string structures, typically a concatenated list of binary digits representing a coding of the parameters for a given problem. Many such structures are considered simultaneously, with the most fit of these structures receiving exponentially increasing opportunities to pass on genetically important material to successive generations of string structures. In this way, GA's search from many points in the search space at once, and yet continually narrows the focus of the search to the areas of the observed best performance.
Simple Genetic Algorithm gives global optimum solution when population size is more but if we increase population size computational time will also increase so to reduce computational time and to increase efficiency of genetic algorithm new technique RGA is proposed. RGA is Refined Genetic Algorithm [19]. Most of RGA subroutines mimic the subroutines in SGA program [8]. However crossover and mutation operators differ between the programs and other difference between the programs are variable probabilities of crossover and mutation operator and the technique Elitism [11]. So RGA provides accurate and feasible solution for economic load dispatch problem with minimum fuel cost. The paper is divided in to three sections. First section discusses introduction, second section discusses problem formulation, and the paper is concluded in the third section.

II. PROBLEM FORMULATION

The economic dispatch problem is to minimize objective function i.e fuel cost, while satisfying several equality and inequality constraints. Generally the problem is formulated as follows.

A. Objectives

The main objective of Economic Dispatch problem is to minimize Fuel cost along with operational constraints and it can be formulated as:

Minimization of Fuel cost: The generator cost curves are represented by quadratic functions and the total fuel cost F in (Rs/h) can be expressed as

$$F = \sum_{i=1}^{N} \left(a_i P_i^2 + b_i P_i + c_i \right) \quad \text{Rs /h} \tag{1}$$

Where P_i is the generated power of i^{th} unit in MW and a_i, b_i, c_i are the cost coefficients of i^{th} generating units, N is total number of generators[5].

B. Constraints

The two constrain while achieving the objectives of ECD problem, Generation Capacity Constraint and Power Balance Constraint can be formulated as:

1) Generation Capacity Constraint: For stable operation, the real power output of each generator is restricted by lower and upper limits as follows:

$P_i^{\min} \le P_i \le P_i^{\max}$ $\quad i = 1,2,...,N$ where P_i^{min}, P_i^{max} are the minimum and maximum limits of power generation of i^{th} generator

2) Power Balance Constraint: The total electric power generation must cover the total electric power demand PD and the real power loss P_L in transmission lines [3].

$$PD - \sum_{i=1}^{N} P_i + P_L = 0 \tag{2}$$

2.1 Implementation of SGA to ECD Problem

Main steps to implement SGA to solve Economic Dispatch problem are as follows:

A. Encoding and Decoding

In order to implement GA's for finding the solution of given optimization problem, variables are first coded in some structure. The strings are coded by binary representations having 0's and 1's.The string in GAs corresponds to "chromosome" and bits in a string refers to "genes" in natural genetics[10]. For power dispatch problems, firstly a population of 20 strings, each of 16 bits, is generated. Then each string in the population is decoded using following Eq.

$$Z_j = \sum_{i=1}^{L} 2^{i-1} b_{ji} \qquad j=1,2,...PS \tag{3}$$

Where L *is* the length of the string, B_{ji} is i^{th} bit in the j^{th} string, Z_j is the equivalent decimal integer of j^{th} binary string in the population, PS is the population size.
From the decoded value of j^{th} string in the population, the value of Lagrange multiplier, λ^j can be found within λ^{min} minimum and λ^{max} maximum limits as under:

$$\lambda^j = \lambda^{min} + \left(\lambda^{max} - \lambda^{min}\right) * Z^j / (2^L - 1) \qquad j=1,2.,PS \tag{4}$$

A. Fitness function

Implementation of power dispatch problem in GAs is realized within the fitness function [6]. Since the proposed approach uses the equal incremental cost criterion as its basis, the constraints can be written in form of error as:

$$\varepsilon^j = PD + P_L - \sum_{i=1}^{N} P_i^j \qquad j=1,2,\ldots,PS \tag{5}$$

In order to emphasize the 'best' chromosomes, the fitness function is normalized into range between 0 and 1. This formula for fitness function is used because in this case it is required to minimize objective function and objective function is fuel cost [16]. The fitness function is adopted is:

$$FF^j = 1/[1 + \varepsilon^j / (PD + P_L)] \qquad j=1,2,\ldots,PS \tag{6}$$

B. Reproduction

For subsequent genetic operation, the Router wheel selection is used. One point crossover is done in SGA. The probability of crossover is 0.5 and the probability of mutation is 0.01 in SGA and these probabilities remain constant for the entire run of the program.0.5 probability means that crossover is performed on only 50 percent of strings [12] . In this case as 20 strings are taken so crossover is performed on only 10 strings [7]. In one point crossover a random crossover site is selected if crossover site is 3 then from third bit onwards bits of parents will be interchanged to produce off springs.

2.2 Implementation of RGA to ECD Problem

Most of the RGA subroutines mimic the subroutines in the SGA program; however the reproduction operators, crossover and mutation differ between programs [9]. While implementing RGA to power dispatch problems, firstly a population of 100 strings, each of 16 bits, is generated. Then each string in the population is decoded. The reproduction operator for RGA is given below:

A. Crossover

Uniform crossover is done in RGA. The probability of crossover varies from 0.7 to 0.6. For every generation, the probability of crossover is exponentially decreased. Limit for crossover probability is 0.6. These limits are set so that the probabilities do not exceed specified standards.

B. Mutation

The probability of mutation varies from 0.001 to 0.1. For every generation, the probability of mutation is exponentially increased. In this a random bit generator is called for each bit and probability of random bit is compared with the probability of mutation and if the random bit is having less probability than mutation then that bit is altered otherwise it will remain same[14]. This process is repeated for all the strings.

C. Elitism

To reduce the computational time of RGA, Elitism is used along with RGA. Elitism compares the results of the most recent population to the elite population. It then combines the two populations and determines the best results from both populations in order of decreasing fitness value [13].
This combination of the most fit **s**tring**s** becomes the elite population. The process continues for each generation so that accuracy and convergence capability can be maintained in RGA.

2.3 Numerical Example and Results

In order to demonstrate the efficiency and the robustness of the proposed genetic algorithm, a 3 Generator system is considered.
The cost equations of three units in Rs/h

$F_1=0.03546\,P_1^2+38.30553P_1+1243.53110$

$F_2=0.02111\,P_2^2+36.32782P_2+1658.56960$

$F_3=0.01799P_3^2+38.27041P_3+1356.65920$

The unit operating ranges in MW are

$35\leq P_1\leq 210$

$130 \leq P_2\leq 325$

$125 \leq P_3\leq 315$

The loss coefficient matrix is

$$B_{mn} = \begin{matrix} 0.000071 & 0.000030 & 0.000025 \\ 0.000030 & 0.000069 & 0.000032 \\ 0.000025 & 0.000032 & 0.000080 \end{matrix}$$

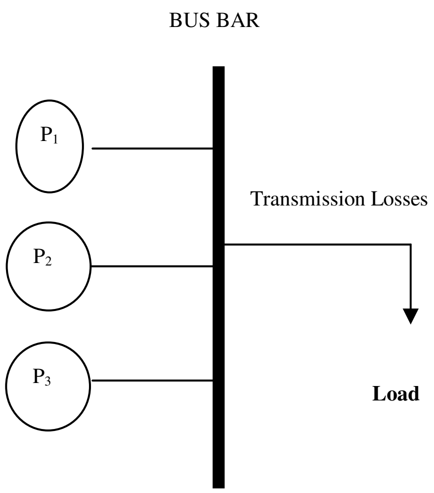

Figure 1: Single line diagram of test system

Power Demand (MW)	Method	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_L (MW)	Fuel Cost (Rs/hr)
400	Conventional Method	81.69	174.94	151.17	7.59	20821.75
	SGA	97.99	211.54	194.12	7.58	20809.34

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	RGA	97.92	211.43	193.99	7.25	20797.98
500	Conventional Method	105.59	212.70	193.43	11.91	25456.35
	SGA	124.73	256.48	246.82	11.1	25423.39
	RGA	124.65	256.35	246.68	10.9	25410.24
600	Conventional Method	129.96	51.03	236.18	17.3	30327.58
	SGA	152.43	303.03	301.42	17.2	30318.86
	RGA	152.22	302.69	301.02	16.5	30282.31

Power Demand=400MW

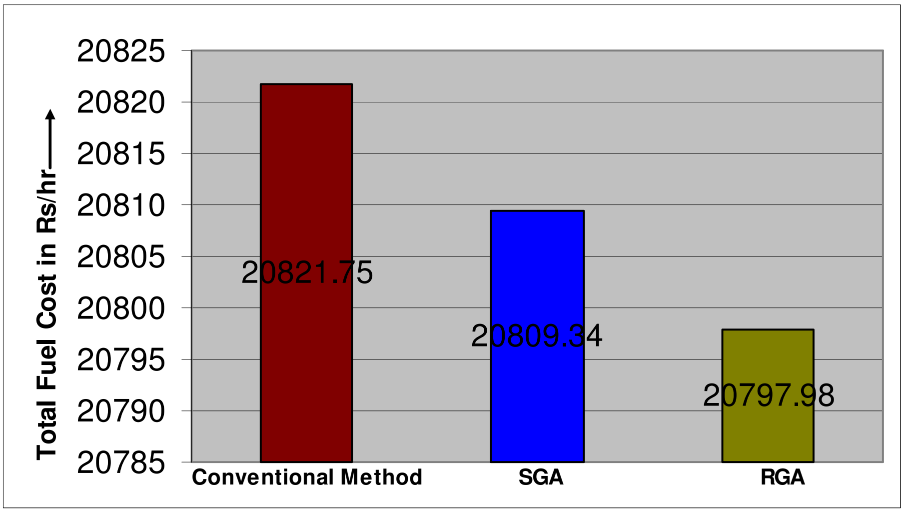

Figure2: Comparison of total cost obtained from conventional method, SGA and RGA for 400MW power demand

Power Demand=500MW

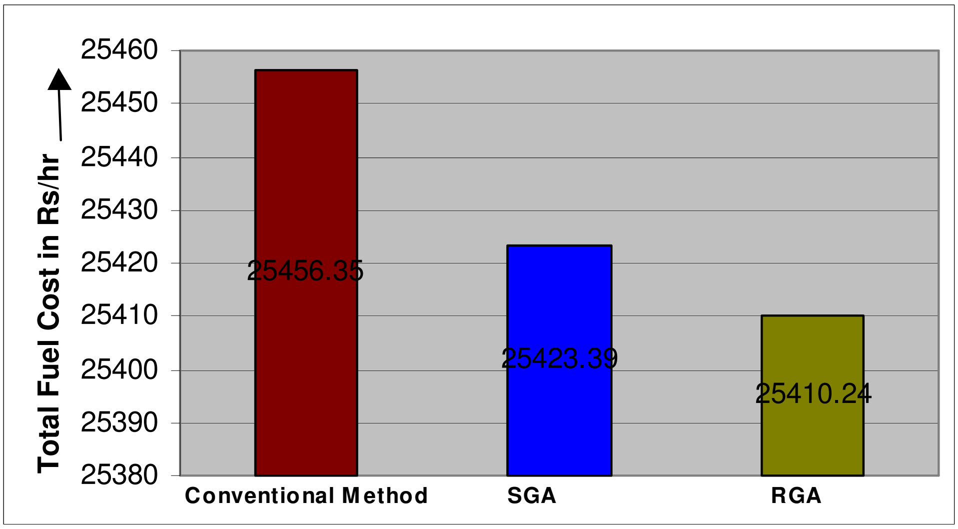

Figure3: Comparison of total cost obtained from conventional method, SGA and RGA for 500MW power demand

Power Demand=600MW

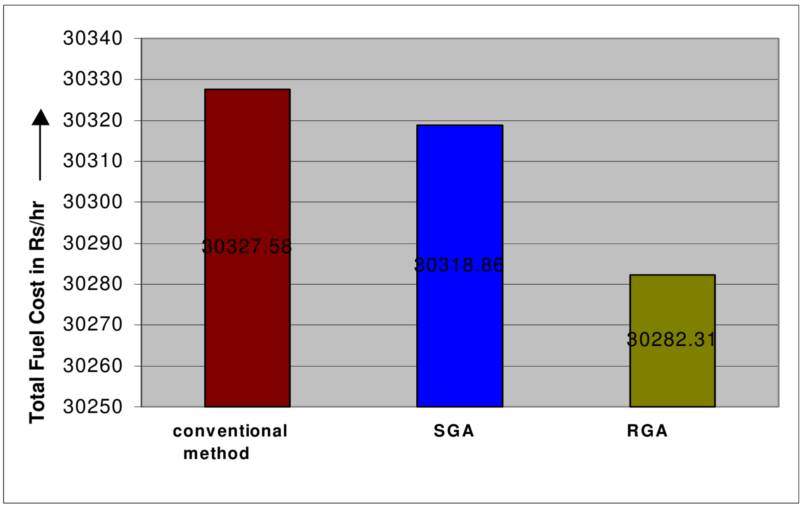

Figure4: Comparison of total cost obtained from conventional method, SGA and RGA for 700MW power demand.

A comparison between SGA, RGA and Conventional Lambda Iteration method (Table 1) has been realized. It is proved in the above figures that the total cost for the various demand are less for the solution obtained by the SGA and RGA. The reliability of the methods also better than the conventional method [15]. The feasibility of the proposed methods is nature of high quality solution, stable convergence and good computation efficiency [20].

III. CONCLUSION

The global solution of ECD problem is found by using SGA and RGA techniques and the results are compared with conventional lambda search method. The results proved that the GA based approaches provide a global optimal solution than the Conventional method. By using the changing probability of mutation and crossover occurrence, computer-processing time can be drastically reduced in RGA method. Elitism is another effective tool to improve the performance capability of genetic algorithms. Because elitism stores the fittest strings from each population, the programs are able to quickly find and keep the best solutions to the problem. When the program converges, it produces natural stopping criteria for the program. The computer usage time can be drastically reduced with implementation of Elitism along with RGA.

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